Iron: A Micronutrient with Macro Importance

Iron Deficiency in Female Endurance Runners

Undergraduate Honors Thesis

Jessica Forster

Oklahoma State University

Honors Thesis Advisor:

Dr. Tay Kennedy

Department of Nutritional Sciences

Oklahoma State University

Honors Thesis Committee:

Dr. Tay Kennedy

Dr. Gena Wollenberg

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ABSTRACT

Objective: The purpose of this study and in creating this handout is to inform female runners about iron deficiency. This provides the runners with the knowledge and if needed, allows them to understand the steps to diagnose their deficiency, and how to treat their deficiency in order to maximize their performance.

Design/Methods: First, I completed a literature review covering the topic of iron loss in female endurance athletes. Secondly, I created a 2-page educational handout on iron loss and prevention based on the research in the literary review following the steps of the Message Development Model outlined by Bauer and Liou (2016). The central issues of causes of iron loss, prevention, and treatment were highlighted on my handout. The creation of the handout followed an emergent design plan where I went through steps of creating, then having others evaluate my handout.

Results: 3 Nutritional Sciences Faculty and 10 female runners ages 18-25 were interviewed. Four major themes emerged after interviewing the Nutrition Faculty: to emphasize the "why do I care?" question, to use attractive graphics, to create an order in my handout, and to emphasize the diet section. The women generally did not understand the importance of iron to running performance before reading the handout. The runner's comments focused on layout and identified areas where additional clarity was needed because of medical jargon or unfamiliar words.

Conclusion: In conclusion, female endurance runners are often undereducated about iron deficiency and what it can do to running performance. This study found that the emergent design strategy for creating a handout was effective in the editing and revising process so that the material is not only attractive and easy to read, but also useful in providing valuable information.

BACKGROUND:

Iron deficiency is widespread; however, it is more prevalent among adult females because of blood loss during monthly menstruation. A specific group of females that are particularly adversely affected by iron loss are endurance runners. When deficient, runners will feel fatigue and running performance will be disrupted. The formation of hemoglobin with iron and the body's subsequent ability to transport oxygen will be impaired in the athlete who is iron deficient. They may experience symptoms ranging from fatigue, weakness, pale appearance, lack of energy, and exhaustion to nausea, infections, uncommon shortness of breath during exercise, and susceptibility to illness. There are many factors that influence iron status including poor diet, blood loss through menstruation, increased levels of training, and inadequate absorption of iron (Alaunyte, Stojceska, & Plunkett, 2015).

Iron is known as an essential trace mineral, as it is needed in our bodies in the amount of 2-4g. It is located in hemoglobin in the blood, stored in myoglobin in the muscles, and is part of enzymes. Two categories of iron include essential iron and storage iron. Essential iron is a necessary mineral that our bodies use to transport oxygen in our blood and provide cellular energy. Storage iron is stored in the form of ferritin and hemosiderin to be kept as a reserve and used when needed (Life Sciences Research Office, Federation of American Societies for Experimental Biology, 2018). Iron is found in two forms in food, as heme and non heme. Heme iron is found in animal products like meat, fish, and poultry, and is derived from hemoglobin and myoglobin. Nonheme iron is found in plant foods like whole grains, beans, and leafy green vegetables. Heme iron is more bioavailable in the foods we eat than nonheme iron. Plants contain a chemical compound known as phytate which alters the chemical composition of iron and does not allow iron to be absorbed as readily as in animal sources (Gropper, Smith & Carr, 2018).

The development of iron deficiency progresses through 3 stages. The first stage of iron deficiency is a decrease in storage iron. This stage is characterized by a decrease in serum ferritin, while transport iron levels and hemoglobin levels stay normal. Serum ferritin is used as a measurement during this stage and is proportionate to the amount of storage iron in our body tissues. The second stage is a decreased supply of iron to cells. This stage is characterized by an increase in Total Iron-Binding Capacity (TIBC) or transferrin, a decrease in transferrin saturation, and normal hemoglobin levels. There is an increased rate of iron transport however; efficiency of transport to erythropoietic cells is decreased during this stage. The third stage is defined as iron deficiency anemia where erythropoietic cells become microcytic (abnormally small red blood cell) and hypochromic (lack of color). This final stage is characterized by an increase in TIBC, decrease in serum iron, decrease in transferrin saturation, an increase in serum transferrin receptors, and reduced hemoglobin. Red blood cells become less functional during this stage because of the reduced hemoglobin (Gropper, Smith & Carr, 2018).

Iron deficiency in female runners has four main causes, the first of which is iron loss due to menstruation. Although females menstruate and lose iron as a natural body function, the loss in female endurance runners can have a significant impact because of their increased training and inadequate consumption of iron. When women lose blood, the amount of iron lost can range from 4mg to 50mg per period (Hytten, Cheyne, & Klopper, 1964). As a result of wide differences in menstrual bleeding patterns, loss will always be different for every woman. However, an average loss of iron during a period is around 2-3mg per day. Research about menstrual blood loss in twins shows a very similar loss per period, suggesting that the amount of blood loss may be related to genetic factors. If iron deficiency is a concern for female runners, menstrual blood loss should be assessed to help determine the effects it has on the individual runner (Harvey et al., 2005).

The training that female endurance runners participate in every week often adds up to many miles and many hours of aerobic exercise. Aerobic exercise is beneficial to health in many ways, however it can cause some degree of iron loss. With increased training load can come four reasons for iron loss including intravascular hemolysis or foot strike hemolysis, iron loss in sweat, gastrointestinal (GI) bleeding, and hematuria. First of all, intravascular hemolysis is the abnormal breakdown of red blood cells from the impact of running. With increased training comes increased impact on a runner's feet which can slowly break down red blood cells and cause the body to lose the hemoglobin that contained the iron (Fazal, Whittemore & DeGeorge, 2017). Secondly, sweat has a small concentration of iron in it and during exercise and sweating the iron can exit the body. This depends on the amount that a person sweats but with increased training can come increased sweat and therefore, iron loss through sweat (Ehn, Carlmark & Hoglund, 1980). Thirdly, gastrointestinal bleeding can be induced by the jarring of exercise on the colon, anti-inflammatory drug use, and GI ischemia (lack of blood supply to the GI organs) (Simons & Kennedy, 2004). Hard running, especially during increased training load periods can be demanding of the body. When maximal intestinal bleeding occurs, a runner can lose from 5 to 27 mg of iron in their stool (Nickerson, Holubets, Weiler, Haas, Schwartz, Ellefson, 1989). Lastly, hematuria is the loss of blood through the urine. As the body uses blood during exercise, blood cells that are damaged are excreted in the urine carrying with it the hemoglobin and iron (Clement & Asmundson, 1982). Hematuria is common in most athletes after long distance running, however along with hemolysis, iron loss in sweat, and GI bleeding, it is important to always monitor bodily functions after running (Fassett, Owen, Fairley, Birch, & Fairley, 1983).

Iron absorption may be disturbed by endurance running. Hepcidin is a protein found in humans that regulates iron circulation in our body. When hepcidin levels are high, such as during inflammatory states, iron absorption is impaired. The constant training and stress on the body as

a result of endurance running is linked to increased inflammation in the body. The theory is that increased inflammation caused by increased training levels will lead to an increase in hepcidin and a decrease in iron absorption. An intensified training period versus a regular training period is where hepicidin levels are most effected (Ishibashi, Maeda, Sumi & Goto, 2017). In a study completed by Peeling et. al., both males and females were divided into 4 groups from low iron status to adequate iron status. They concluded that after athletes trained, their hepcidin levels did rise due to inflammation. However, this only occured in the groups where the athletes already had adequate iron stores. In the groups where the athletes already had low iron stores hepcidin decreased rather than increased, even with the increase in inflammation caused by training. This indicates that although hepcidin usually increases with inflammation, the baseline iron stores for an athlete have more effect on hepcidin and its ability to maintain iron homeostasis within the body (Peeling et. al., 2014).

In order to maintain the body's iron stores through dietary intake, the recommended daily allowance for women is 14 mg. The body uses about 5-10% of that dietary iron to replenish iron losses that occur day to day. In a study completed by Clement and Asmundson in 1982, 52 college middle distance and long distance runners were evaluated based on their dietary intake of iron and how it affected their iron status. Along with a dietary recall, two blood tests were performed to measure serum ferritin, and other iron parameters. After the 7 day recall, the results showed that 90% of the female runners were not meeting the recommended daily intake of iron. The study found that the females mean dietary iron intake was 12.5 mg, which is below the RDA. Subsequently, the average serum ferritin levels of the women were approximately 3 mg lower than normal range. This highlights that while many causes play into endurance runners having iron deficiency, a low intake of dietary iron is indicative of low iron stores (Clement & Asmundson, 1982).

In healthy red blood cells, hemoglobin is an iron binding protein that helps deliver oxygen to tissues throughout the body. When iron loss reaches the third stage characterized by low hemoglobin, red blood cells are no longer able to carry out their full function. This is when anemia occurs. The symptoms that occur from low levels of hemoglobin and iron deficiency are variable and present themselves differently in each person. During the early signs of anemia symptoms may be unrecognizable because of the body's ability to compensate for a small loss in iron. Often, the most common symptoms will be fatigue and exhaustion in performance and in daily activities. Other symptoms are pale skin and pale mucous membranes, rapid heartbeat, shortness of breath, fainting, headaches, and lessened immune system functioning (Sacirovic et al., 2013).

The combination of all of these causes lead to a compounding loss of iron that progresses through the three stages of deficiency as highlighted previously. As the iron in hemoglobin transports oxygen through the body, there is a greater demand of oxygen during an athlete's performance in sports. Endurance sports, especially running, are highly aerobic. Endurance athletes need hemoglobin to effectively transport oxygen to their muscles in order to maximize their performance (Garza et al., 1997). When women are losing an average of 2-3mg/day from menstruation, iron from hemolysis, and inadequately absorbing iron, it is necessary to be able to restore that loss so that they can lower their risk of iron deficiency.

Before treatment, testing needs to be done in order to confirm iron deficiency. A runner that suspects iron deficiency as a result of abnormal symptoms of performance should visit their primary care doctor in order to then be referred to get a blood test (Pedlar, Brugnara, Bruinvels, & Burden, 2017). A blood test can measure serum ferritin, serum transferrin receptor concentration, iron binding capacity, hemoglobin and more biological measures (Nickerson et al., 1989). These measures will show the amount of iron that is stored in the blood. Hemoglobin

is a common test and very easy to perform however it doesn't indicate early stages of iron deficiency (Gropper, Smith & Carr, 2018). Serum ferritin is one of the more specific tests to monitor storage iron and can range from amounts of 12 to 135 ng/ml measured in the blood. Although there is a wide range of acceptable ferritin levels, the lower the ferritin levels, the higher likelihood of iron deficiency and decreased performance. The most accurate indicators of iron deficiency in female endurance athletes includes a combination of low hemoglobin and low serum ferritin. (Garza et al., 1997)

After testing and conformation of iron deficiency, there are treatment options to explore. Diet is the encouraged form of treatment for iron deficiency because there are a wide variety of foods that naturally provide adequate iron to support a female runner's needs. The recommended daily allowance for iron is 17.0–18.0 mg/day in women 19 and older. The effects that losses of iron due to exercise and menstruation can have on female endurance runners may result in a 70% increased need in iron requirements (Alaunyte, Stojceska, & Plunkett, 2015). Dietary sources of iron that are most bioavailable include heme iron such as red meat, fish, and poultry. Sources of iron that are not as bioavailable include green vegetables, dried fruits, beans, and fortified whole grains. Combining the animal sources of iron and plant based sources of iron will improve absorption (Gropper, Smith & Carr, 2018).

Foods rich in vitamin C will also help improve iron absorption. The ascorbic acid in citrus foods acts as a reducing agent meaning that they reduce ferric iron to ferrous iron, the form that is taken up into the cells. For example, a spinach salad with strawberries or mandarin oranges would provide both good sources of iron and vitamin C for the best absorption. Foods high in calcium will decrease absorption. Calcium inhibits iron absorption by causing the iron transporter on the enterocyte to temporarily relocate and not allow the iron to fully absorb

(Gropper, Smith & Carr, 2018). Dietary sources of iron are highly important in maintaining iron status, especially during intensive training periods (Alaunyte, Stojceska, & Plunkett, 2015).

The use of supplements in treating iron deficiency is common. Fifty percent of women ages 19-30 living in the United States take dietary supplements according to the National Health and Nutrition Examination Survey, 2016. Out of those women, about 15% take a supplement that includes iron. This indicates that women are aware that iron supplementation is available, however not many take them and iron deficiency continues to be a problem. In most cases, iron requirements can be met through dietary intake. Supplementation is best used in athletes who have diagnosed iron deficiency anemia, or who do not receive satisfactory amounts of iron through diet. Supplements are available in the form of salts and heme supplements (DellaValle, 2013). Iron supplements that provide 30-65 mg per day are recommended. It can take up to 2 weeks of treatment to show improvement in red blood cell count and hemoglobin levels (Gropper, Smith & Carr, 2018). Supplementation should be monitored as taking more than 65 mg leads to risks of toxicity with too much iron. Risks of excess iron may contribute to heart disease, diabetes, and certain cancers (Sacirovic et al., 2013).

The effects of iron deficiency on a female runner's body can be detrimental to performance because of the important role iron has in transporting oxygen to the muscles. While menstruation is a natural bodily process and contributes to the loss of iron in females, the combination of increased training, insufficient diet, and insufficient absorption create a formula for iron loss. Ensuring sufficient dietary intake of heme iron, as well as a nutrient rich diet to ensure energy balance, is likely the best form of prevention of iron deficiency for female endurance runners (Coates, Mountjoy & Burr, 2017). Iron status may take anywhere from 3 months to 1 year to fully improve. A female runner looking for the best improvement should

regularly monitor her iron intake over periods of training and periods of treatment and non-treatment (Pedlar, Brugnara, Bruinvels, & Burden, 2017).

METHODS:

The purpose of this project is to compile knowledge into a literary review in order to create an educational handout for female endurance runners about iron deficiency. This project was reviewed and approved by the Institutional Review Board at Oklahoma State University to complete a human subjects study (Appendix 1).

Participants: The participants in the research included 3 female nutrition professors. I recruited professors who had a background in nutrition and physical activity, as well as a background in nutrition education. The second group of participants included 10 females, ages 18 to 25, who self-identify as endurance runners. These runners were not to have a background in nutrition or major in nutrition.

Materials: Informed consent forms containing information about procedures, risks and benefits of participation in the study, confidentiality, participant rights, and contact information of the researchers were used (Appendix 2). Additional materials used included the outline of the educational handout and the handout itself. The outline of the handout was created as a preliminary document to highlight the main topics on the official handout. The educational handout included topics detailing the mechanism, symptoms, and treatment of iron deficiency. For the evaluation of the outline and handout, two sets of interview questions were used. The first group of interview questions were for nutrition professors that evaluated if the content on the handout was sufficient and valid (Appendix 3). The second group of interview questions were for runners. These questions covered the content, graphics, and usefulness of the handout in educating the runner on iron deficiency (Appendix 4).

Procedure: First, background information was collected on the topic in the form of a literary review. After the background information was compiled and a handout outline completed (Appendix 5), I recruited professors in Nutritional Sciences (Appendix 6). I met with them to obtain informed consent, gave them time to review my outline, then recorded their responses. Each interview took approximately 30 minutes.

For the second component of my research, I created the first draft of my final handout to be evaluated by female endurance runners (Appendix 7). The handout highlighted the central issues of iron loss by explaining the four main causes of iron deficiency in female endurance runners. It also explained key concepts of iron loss prevention and treatment to create a well-designed and concise handout. To recruit runners, I started with personal contacts from groups in which I am involved (Appendix 8). Once I recruited personal contacts, I asked them if they had friends who would be willing to participate. Through the snowball method, I gathered the remaining contacts that I needed.

The creation of my handout followed an emergent design plan where I went through the steps of creating, then allowed others to evaluate my handout (Bauer, & Liou, 2016). After interviewing professors and creating the handout with their advice, I interviewed 10 female runners. Each runner was initially asked if they had any prior knowledge on the subject of iron deficiency with the acceptable answer being any details they knew even if it was nothing. The rest of the runner's interview consisted of eight Likert scale questions where the runners gave me feedback on categories of content, appeal, layout, and usefulness, and five open-ended suggestion questions. Answer options for the likert scale questions ranged from 1-5 with one being disagree, 5 being agree, and 3 being neither agree or disagree. I presented my initial handout to the first three runners. As a result of their advice, I edited my handout and presented it again to four more runners. I edited my handout once more and presented it to the final set of

three runners. Lastly, I edited and revised my handout based on their feedback in order to create the most effective educational tool for my target audience (Appendix 9).

RESULTS:

Table 1 summarizes the emerging themes and provides sample comments that I found in completing the interviews with the Nutrition Professors.

Table 2 summarizes the results from the female runner's interviews. The majority of the runners had very little knowledge about iron, however they knew there was some importance in having a satisfactory level of iron in the body. One of the runners had experience with anemia, however she did not know that it could affect her running performance. Two of the runners had a wide knowledge of the subject because they have been educated about iron deficiency from previous coaches or doctors. In response to the Likert scale questions, the results revealed that the runners agreed with an average score of 4-5 that the information and layout were instructive, appealing, and useful. I then developed emerging themes and received comments from the female runners using feedback from the open-ended suggestion questions.

Table 1: Emerging themes from Nutrition Professors review of outline.

Question 1: Are there any topics that you think should be added to the handout?	
Emerging Themes	**Sample Comments**
The effects of training and exercise on iron deficiency.	*"Include more about how a runner's training can lead to iron loss."* *"Incorporate information about how a runner's normal diet might not provide sufficient iron."*
More specifics under the dietary intake section.	
Costs of tests to run (serum ferritin, hemoglobin)	
Question 2: Are there any topics you feel deserve more emphasis on the handout than others?	
Emerging Themes	**Sample Comments**
Why do I care? (Symptoms and Consequences)	*"The runners want to know the 'why do I care,' so they know why reading your handout should matter to them."* *"Emphasize testing before supplementation because even though it is rare, iron toxicity can be a danger."*
Treatment of iron deficiency through dietary options	
Importance of testing iron deficiency before supplementing.	
Question 3: Do you have any other suggestions for me in creating the handout?	
Emerging Themes	**Sample Comments**
Evaluate subjects, and tailor the handout towards what they understand about iron deficiency.	*"Determine where your subjects fall in the stages of change model. If most of them fall in the precontemplation stage, make sure you focus your handout on background information."* *"Include pictures to break up the writing"*
Use pictures	
Website for reference should be sports related	

Table 2: Emerging themes from runner's interviews after review of the handout.

Question 1: What did you like best about the handout?	
Emerging Themes	**Sample Comments**
Written in an effective way to provide necessary and useful information. The handout has a natural flow. The treatment is applicable. Color choice.	*"I like the balance of words, graphs and blurbs."* *"The order of the layout has a nice flow."* *"Easy to read; My eyes were able to follow the progression of the pictures with words."* *"Even if someone isn't interested at all, I think it's important to have a take away and what we or I could do for this."*
Question 2: What did you like least?	
Emerging Themes	**Sample Comments**
After first draft of handout: – Lack of explanation on the back – Color contrast between text and background	*"I don't understand what the bubbles mean on the back because you don't explain them."* *"Dark pink words on the pink background need to be darker."* *"The colors make it look like an old handout found in a hospital."*
After second draft of handout: – Layout of the treatment section – Abundance of information and difficult words.	*"Layout of the treatment part is a little bit busy."* *"I didn't really understand the big words."* *"There is a lot of information for one handout."*
After third draft of handout: – Nothing	
Question 3: What, if anything, would you change about the layout?	
Emerging Themes	**Sample Comments**
Layout of treatment section The DIET diagram	

Nothing, the layout is understandable and it flows.	*"Maybe put the treatment section in 3 columns. For example: diet, supplements, and then resources."* *"The DIET thing is hard to read because the words are small."* *"It makes sense: symptoms to diagnosis to treatment."* *"I think it looks great and is visually enticing."*
Question 4: What suggestions do you have that might help me improve this handout as a whole?	
Emerging Themes	**Sample Comments**
Condense and review the writing	*"If possible to condense the content a smidge to help readers stay interested and attentive to great information."* *"There is a lot of info in the causes section, Maybe decrease the amount of words."* *"Maybe just changing the color of the font."* *"Under symptoms where it says "decrease in immune system," maybe use a different word than decrease."*
Edit the colors	
Question 5: Is there anything else you would recommend regarding the handout?	
Emerging Themes	**Sample Comments**
Condense the writing	*"There is a lot of writing on the first page"* *"Try using a .png image for the salad, so you don't have a weird background."* *"I don't normally like to read things, but this is designed in a way that makes me want to read it.* *"Very insightful! You should print it and put it up somewhere."*
Make graphics uniform	
Attractive design	

DISCUSSION:

In summary, consistent with the emergent design, I worked to implement every suggestion I received. After talking to the nutrition professors, I decided to focus on the design of the handout while keeping the words as concise and informative as I could. The main points that the professors gave me were to emphasize the "why do I care?" question, to use attractive graphics, to create an order in my handout, and to emphasize the diet section. In order to highlight the "why do I care?", I worked to find a creative title to hook the audience. I also included text on the front page that reinforced iron deficiency as a condition that cause a decrease in running performance. I included colorful graphics to catch the eyes of my readers. I followed the outline order so that the readers could follow the handout in the correct order. For example, I made sure that the diagnosis section came before the treatment section as well as explaining the importance of having a blood test before treating for iron deficiency. Finally, I created a diagram in the diet section to emphasize the importance of diet options for treatment.

Continuing after the first draft of the handout, the emergent design of this study helped me develop the handout so that it could be directly applicable to female runners by being edited by female runners. After showing the handout to the first group of runners, they suggested that I change some of the layout and technical explanations of the material. I switched the order of the causes and symptoms, and I explained the diagnosis section better in response to the comments. Both the first and second groups of runners commented on the color of the handout. In order to make my handout more attractive to my audience, I updated my colors to be brighter and more enticing. I also changed my font to a clean, sharp, sporty typeface to create a more attractive handout for my audience. Finally, the last group gave me small tips to follow such as the spacing of lines or the use of certain words. After this round, I minimally edited my handout to change

spacing and some of the layout of the diet section. However, as I received suggestions in this round I did not edit my handout unless I was given a suggestion more than once.

After studying iron deficiency, creating an educational handout, and interviewing female runners, I learned that the general knowledge of iron deficiency, such as what it is, how it happens, and how to prevent it, is limited. Most of the runners in the group that I interviewed had a basic understanding, but commented that much of the information provided in the handout was new. That has been found to be the common knowledge among female endurance runners, therefore iron deficiency may continue to be a problem and female runners may not perform to the best of their abilities consistently (Merritt, 2013). I expected this result to an extent. As a student in nutritional sciences, I forget that not everyone comes or across nutrition information on a daily basis. More research is needed in order to further the knowledge that we have on the nutrition education of female endurance runners. For this reason, there are positive implications for this study and its insight into creating a handout for the purpose of educating a specific group on a topic.

Nutrition education often begins with evaluating a subject's stage of understanding, providing a source of knowledge, then revisiting the topic in a way that solidifies the learning. The most effective education materials are those that are simple, enticing, interactive, and motivating (Frazão, 1999). This was the aim in the handout that I created. The handout contained a lot of information, however it was targeted to a specific purpose as to not overwhelm the reader. It was applicable to the age group and had a sporty theme that could be relatable. It was motivating because it explained that iron deficiency could affect their performance so it is important to take action when symptoms develop. The positive outcomes that can result from the design include, more people being drawn into the design initially thus allowing them to read and

learn more about the information provided by the handout. As a result of its comprehensibility, it may be a tool that nutrition professionals are willing to pass on to their patients.

Some limitations of my study included a small sample size and there was no evaluation implemented. The Likert scale questions provided a lead in to allow runners to become comfortable and more open to answer suggestion questions. Although my study was not large enough for significant results, the likert scale allows for statistical testing of survey results. In a further study, this method could be carried out in the same way with a larger sample size so that the results could be statistically tested. Secondly, in order to evaluate a program or education's effectiveness an evaluation is a helpful tool. In this case, a process evaluation would be the most helpful because it monitors the program implementation as well as the program outcome (Saunders, Evans & Joshi, 2005). This would be helpful in order to determine the impact the handout had on the runners as well as if any of the knowledge was absorbed.

In conclusion, my favorite comment was "*Very insightful! You should print it and put it up somewhere."* This was a comment from a runner after I created my last draft of my handout. The goal in creating this handout was to develop an education that would be appealing to female endurance runners in order that they would have the option of using it for their knowledge. From the feedback I received, this handout could be placed in places that would allow it to reach female runners to further education about iron deficiency. These places include gyms or recreation centers, running supply stores, locker rooms of high school and college runners, or health centers. Whether they are presented by a nutrition professional or placed on a stand with other handouts, the importance is that the handouts would be accessible and spread important information about iron deficiency that a female runner may not have previously known.

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APPENDIX 1

Oklahoma State University Institutional Review Board

Date:	03/23/2018
Application Number:	HS-18-12
Proposal Title:	Iron Deficiency and Treatment in Female Endurance Runners
Principal Investigator:	Jessica Forster
Co-Investigator(s):	TAY KENNEDY
Faculty Adviser:	TAY KENNEDY
Project Coordinator:	
Research Assistant(s):	
Processed as:	Exempt

Status Recommended by Reviewer(s): Approved

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 223 Scott Hall (phone: 405-744-3377, irb@okstate.edu).

Sincerely,

Hugh Crethar, Chair Institutional Review Board

APPENDIX 2

ADULT CONSENT FORM
OKLAHOMA STATE UNIVERSITY

PROJECT TITLE: Honors Thesis: Iron Deficiency and Treatment in Female Endurance Runners

INVESTIGATORS:
Jessica Forster, Nutritional Sciences
Tay Kennedy, Ph. D Nutritional Sciences

PURPOSE:
This study will examine the value of a handout describing iron deficiency and treatment for female endurance runners.

PROCEDURES
I will be asking you to review and asses the content that I am including in my handout. I will allow you time to look over the handout, then I will have a set of questions to ask you. I will record your answers to my questions on paper. This study is designed to last approximately 20 minutes.

RISKS OF PARTICIPATION:
There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.

BENEFITS OF PARTICIPATION:
There is no expected benefit for participation in this study. If you are interested, we will send you a copy of the final handout when it is finished.

CONFIDENTIALITY:
The records of this study will be kept private. Any written results will discuss collective findings and will not include information that will identify you. Research records will be stored in a folder in a locked office and only researchers and individuals responsible for research oversight will have access to the records. The results from the survey will be anonymous, and only the researchers will know your identity. Data will be kept until one year after the study has been completed.

COMPENSATION:
There will be no compensation for your participation.

CONTACTS :
You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Jessica Forster, Nutritional Sciences Undergraduate, jessica.forster@okstate.edu,

03/23/2018
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(512)-694-7109, or Tay Kennedy, Ph.D., College of Human Sciences, Dept. of Nutritional Sciences Oklahoma State University, Stillwater, OK 74078, tay.kennedy@okstate.edu, or (405) 744-5965. If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

PARTICIPANT RIGHTS:
I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:
I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:
I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

_____ _____
Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

_____ _____
Signature of Researcher Date

03/23/2018
HS-18-12

APPENDIX 3

Interview Questions for Professors

10 minutes to review the outline of the information for the handout.

1. Are there any topics that you think should be added?
2. Are there any topics you feel deserve more emphasis on the handout than the others?
3. Do you have any other suggestions for me in creating the handout?

APPENDIX 4

Female Runners Handout Interview

I will allow time for the interviewee to read over the handout.

Content

1. Before reading this handout, what knowledge, if any, did you have about iron deficiency in female endurance runners?

For the next questions please answer using a scale of 1 to 5 with one being disagree and three being neither agree or disagree and 5 being agree.

2. The handout content is easy for me to understand.

   Agree Neither Agree nor Disagree Disagree

3. The handout is written appropriately for the intended audience (female adult endurance runners)

   Agree Neither Agree nor Disagree Disagree

4. The overall handout is appealing.

   Agree Neither Agree nor Disagree Disagree

5. The handout layout is easy to follow.

   Agree Neither Agree nor Disagree Disagree

6. The handout graphics are visually appealing.

   Agree Neither Agree nor Disagree Disagree

7. The handout graphics are helpful.

   Agree Neither Agree nor Disagree Disagree

8. The handout content is useful to you as a female runner.

   Agree Neither Agree nor Disagree Disagree

Suggestions

1. What did you like best about the handout?

2. What did you like least?

3. What if anything would you change about the layout?

4. What suggestions do you have that might help me improve this handout as a whole?

5. Is there anything else you would recommend regarding the handout?

Would you like to read over the notes I have taken to confirm that your responses are accurately recorded? Yes No (circle one)

Thank you for helping me with my honors thesis.

APPENDIX 5

Iron Deficiency and Treatment in Female Endurance Runners

Outline of Educational Handout

1. Front Page: Iron Deficiency
    a. Background and mechanism: who is at risk and why
        i. Short description of anemia
        ii. Symptoms and consequences
        iii. include a picture on handout of mechanism
    b. Causes of iron deficiency in female endurance runners
        i. Poor dietary intake of iron
        ii. Iron loss through menstruation
        iii. Increased levels of training
        iv. Inadequate absorption of iron
    c. Symptoms
2. Front/Back Page: Diagnosis of Iron deficiency
    a. Where do you go to get a diagnosis?
    b. How do you get diagnosed?
3. Back Page: Treatment for Iron deficiency
    a. Iron supplementation
    b. Diet rich in iron that is more bioavailable
    c. Web site for further information

APPENDIX 6

Recruiting Script for Nutritional Sciences Faculty to be e-mailed

Hello, my name is Jessica Forster. I am a completing my undergraduate honors thesis in the department of Nutritional Sciences. My thesis includes a literary review where I have gathered topics about iron deficiency in female endurance runners and treatment which will be used to create an educational handout. I am asking for your help because of your expertise in nutritional sciences I have created an outline of topics for my educational handout which I will be asking you to review an outline to access the content that I am including in my handout.

Participation in this interview includes signing a consent form, which will take approximately 5 minutes. If you agree to participate, I will interview you about your view of the topics I have chosen to focus on in my educational handout. This will take approximately 20-30 minutes. If you participate in both the consent and the interview, your total time commitment will be between 25 – 35 minutes.

If you have any questions or would like to participate in the research, I can be reached at jessica.forster@okstate.edu or 512-694-7109. If you have further questions, my honor's thesis advisor can be reached at tay.kennedy@okstate.edu.

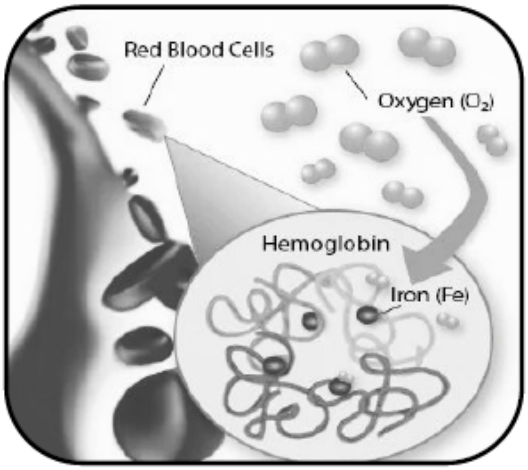
03/23/2018
HS-18-12

APPENDIX 7

Iron: Micronutrient with Macro Importance

You can't run efficient if you're deficient!

Iron deficiency is one of the most common nutritional deficiencies for female endurance runners. Iron is mainly used in the body to help the hemoglobin in red blood cells transport oxygen for use in the rest of the body.



Symptoms

- ⇒ Fatigue
- ⇒ Weakness
- ⇒ Decrease in Energy
- ⇒ Shortness of breath
- ⇒ Decrease in Immune System

Running, as an aerobic exercise, increases the need for oxygen in the muscles. If there is not iron in the blood to transport the oxygen, The muscles will become fatigued and running performance will decrease.

Causes of Iron Deficiency in Female Runners

Iron loss through menstruation

When women lose blood through menstruation, they can lose iron stores up to 2-3mg/day. If the iron is not replenished, over time this can lead to iron deficiency.

Increased levels of training

Running is a sport that takes a physical toll on the body. The repetitive motion of feet pounding on pavement can cause a condition called foot strike hemolysis. This is the destruction of red blood cells which can lead to a loss of iron stores in the body.

Poor dietary intake of iron

Many female runners do not eat a diet sufficient in iron to support losses. The body uses about 5-10% of that dietary iron to replenish iron losses that occur day to day. A low intake of dietary iron is indicative of low iron stores.

Inadequate absorption of iron

Iron absorption may be disturbed by endurance running. Hepcidin is a protein found in humans that regulates iron circulation in our body. When hepcidin levels are high, such as during inflammatory states, iron absorption is impaired.

Diagnosis

- ⇒ A primary care physician will have you get a blood test.
- ⇒ It is important to check with your doctor and go for testing before you get treatment.

Serum Ferritin: Indicates the amount of iron stores in your body.

Hemoglobin: Test to measure Red Blood Cell Count.

Treatment

Diet

Sources of Iron
- ⇒ Lean meat
- ⇒ Legumes
- ⇒ Leafy green vegetables
- ⇒ Dried fruit
- ⇒ Enriched whole grains

Example: Spinach salad with vitamin C source.

DIET

- Don't just eat one source of iron; vary your food choices.
- Include Vitamin C with Iron rich foods to help with absorption.
- Exclude calcium during iron rich meals because it inhibits absorption.
- The Recommended Daily Allowance is 18 mg/day for adult women.

Supplementation

Iron supplements that provide 30–65 mg (but sometimes as high as 120 mg) of iron are recommended. Can take up to 2 weeks to show improvement in Red Blood Cell count and hemoglobin levels.

Iron therapy to increase body stores of iron may be needed for 3 months to 1 year.

Resources for extra information:

Iron deficiency in running: https://www.active.com/articles/when-fatigue-slows-you-down-iron-deficiency-anemia

General Iron Deficiency: https://www.mayoclinic.org/diseases-conditions/iron-deficiency-anemia/symptoms-causes/syc-20355034

APPENDIX 8

Recruiting Script for female endurance runners

Hello, my name is Jessica Forster. I am a completing my undergraduate honors thesis in the department of Nutritional Sciences. I am conducting research on iron deficiency and treatment for female endurance runners and am asking for your help because of your running experience. My thesis includes a literary review where I have gathered topics about iron deficiency and treatment which will be used to create an educational handout. I will be asking you to review my educational handout and answer questions about its content and layout.

Participation in this interview includes signing a consent form, which will take approximately 5 minutes. If you agree to participate, I will have you look over my handout and answer questions about it in an interview. This will take approximately 20-30 minutes. If you participate in both the consent and the interview, your total time commitment will be between 25 – 35 minutes.

If you have any questions or would like to participate in the research, I can be reached at jessica.forster@okstate.edu or 512-694-7109. If you have further questions, my honor's thesis advisor can be reached at tay.kennedy@okstate.edu.

APPENDIX 9

IRON: MICRONUTRIENT WITH MACRO IMPORTANCE

You can't run efficient if you're deficient!

Iron deficiency is one of the most common nutritional deficiencies for female endurance runners. Iron is mainly used in the body to help the hemoglobin in red blood cells transport oxygen for use in the rest of the body.

CAUSES OF IRON DEFICIENCY IN FEMALE RUNNERS

Iron loss through menstruation

When women lose blood through menstruation, they can lose iron stores up to 2-3mg/day. If the iron is not replenished, over time this can lead to iron deficiency.

Increased levels of training

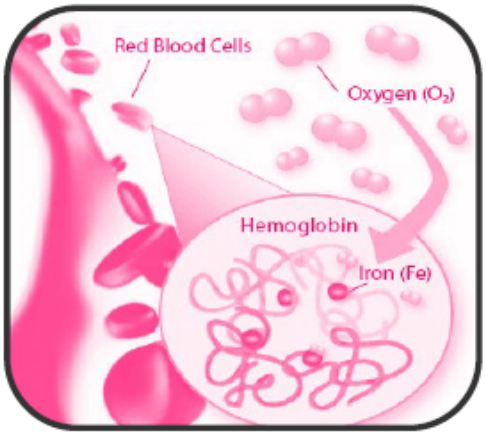
Running is a sport that takes a physical toll on the body. The repetitive motion of feet pounding on pavement can cause a condition called foot strike hemolysis. This is the destruction of red blood cells which can lead to a loss of iron stores in the body.

Poor dietary intake of iron

Many female runners do not eat a diet sufficient in iron to support losses. The body uses about 5-10% of that dietary iron to replenish iron losses that occur day to day. A low intake of dietary iron is indicative of low iron stores.

Inadequate absorption of iron

Iron absorption may be disturbed by endurance running. Hepcidin is a protein found in humans that regulates iron circulation in our body. When hepcidin levels are high, such as during inflammatory states, iron absorption is impaired.



SYMPTOMS

- ⇒ Fatigue
- ⇒ Weakness
- ⇒ Decrease in Energy
- ⇒ Shortness of breath
- ⇒ Decrease in Immune System Function

Running increases the need for oxygen in the muscles.

If iron is not in the blood cells to transport the oxygen, the muscles will become fatigued and running performance will decrease.

DIAGNOSIS

- ⇒ Ask your doctor for a blood test
- ⇒ Get tested before treating yourself
- ⇒ Talk to a sports dietitian about your diet.
- ⇒ Most important measures of iron in your blood

SERUM FERRITIN:
Indicates the amount of iron stores in your body.

HEMOGLOBIN:
Test to measure Red Blood Cell Count.

TREATMENT

DIET

- Don't just eat one source of iron; vary your food choices.
- Include Vitamin C with Iron rich foods to help with absorption.
- Exclude calcium during iron rich meals because it can inhibit absorption.
- Try to eat 18 mg/day of some form of dietary iron.

EXAMPLE: SPINACH SALAD WITH VITAMIN C SOURCE.

SOURCES OF IRON

- ⇒ Lean meat
- ⇒ Legumes
- ⇒ Leafy green vegetables
- ⇒ Dried fruit
- ⇒ Enriched whole grains

SUPPLEMENTATION

Iron supplements that provide 30–65 mg of iron are recommended.

It can take up to 2 weeks to show improvement in Red Blood Cell count and hemoglobin levels.

Iron therapy to increase body stores of iron may be needed for up to 1 year.

RESOURCES FOR EXTRA INFORMATION:

Iron deficiency in running:

https://www.active.com/articles/when-fatigue-slows-you-down-iron-deficiency-anemia

General Iron Deficiency:

https://www.mayoclinic.org/diseases-conditions/iron-deficiency-anemia/symptoms-causes/syc-20355034

Handout completed by Jessica Forster